

The background of the slide is a photograph of Earth taken from space. It shows a curved horizon with a bright blue sky and a dark blue ocean. White clouds are visible over the landmasses. The image is slightly tilted, giving a sense of being in orbit.

# **NOAA's Space Weather Prediction Testbed: Research to Operations Operations to Research**

Rodney Viereck, SWPT Director

Presentation to the Test Bed Proving Ground Annual Meeting  
5 April, 2016

# Outline:

- Accomplishments of last year
- Plans for the coming year
- High level directives (OSTP/OMB) Directives for Space Weather
  - Introduction of new R2O and O2R Centers for Space Weather

## SWPT Mission

**Accelerate and improve the quantitative use of scientific research in space weather specification and prediction to improve forecasts, alerts, watches, warnings and products for customers.**

# SWPT Staff and Funding (FY 14)

- 24 PhD scientists (6 Fed, 18 CU/CIRES)
- FY14 Non Fed Funding:
  - 60% NOAA,
  - 30% NASA Grants,
  - 10% NSF/AFOSR Grants
- New Staff
  - Magnetosphere scientific programmer: (Selection Made) GS 13-14
  - Solar wind scientist programmer (CIRES)
  - Ionosphere programmer (CIRES)
- Hiring soon (FY16)
  - Ionospheric scientific developer (CIRES)
  - Whole Atmosphere Model (WAM) developer (CIRES)

# Modeling and Data for Space Weather Forecasting

(Partnering with the World)

## Sun:

ADAPT (USAF)  
WSA (USAF)  
SDO (NASA)  
RSTN (USAF)  
GONG Solar Magnetograms (National Sol. Obs.)  
Flare Prediction (SBIR)  
Fareside Solar Imaging (SBIR)  
EUV Irradiance (SWPC)

## Solar Wind:

Enlil (G. Mason U.)  
DSCOVR (NASA DOD)  
L1-Earth Transit (SWPC)

## Magnetosphere:

GOESPACE (U. Mich.)  
GOES Magnetopause Model (SWPC)

## Ionosphere:

IPE (SWPC)  
US-TEC (SWPC)  
NA-TEC (SWPC)  
Global TEC (SWPC)  
COSMIC II (NESDIS)  
Ground GPS Data  
GOLD (NASA)  
ROTI (SBIR)  
Equatorial Scintillation (SWPC)

## Aurora:

30 Minute Forecast (JHU)  
3 Day Forecast (SWPC)

## Thermosphere

WAM (SWPC EMC)  
CTIPe (SWPC)

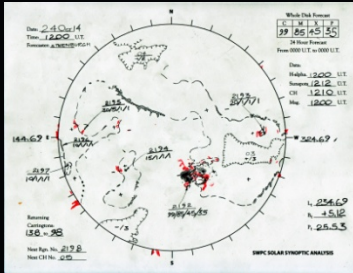
## Ground:

E-Field (SWPC, USGS, NASA)  
Airline Radiation (NASA)

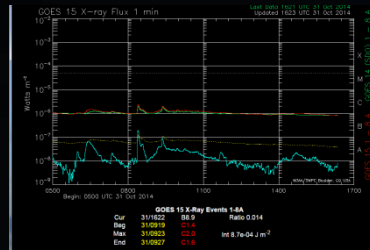


## Current SWPC Products

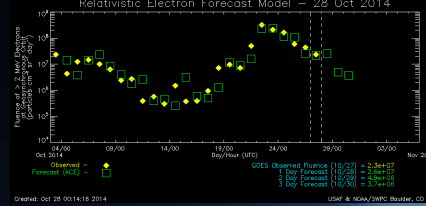
## Synoptic Drawings



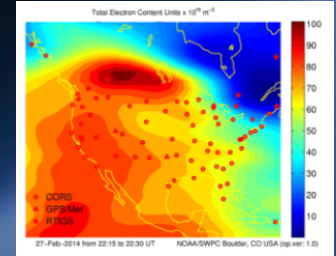
## Solar X-ray Flux



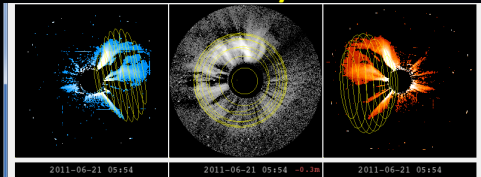
# Relativistic Electron Forecast Model



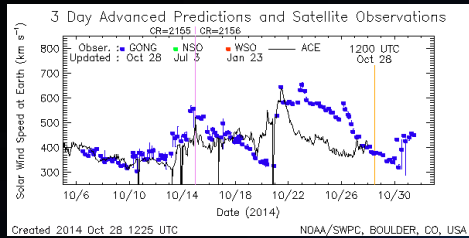
## US-TEC



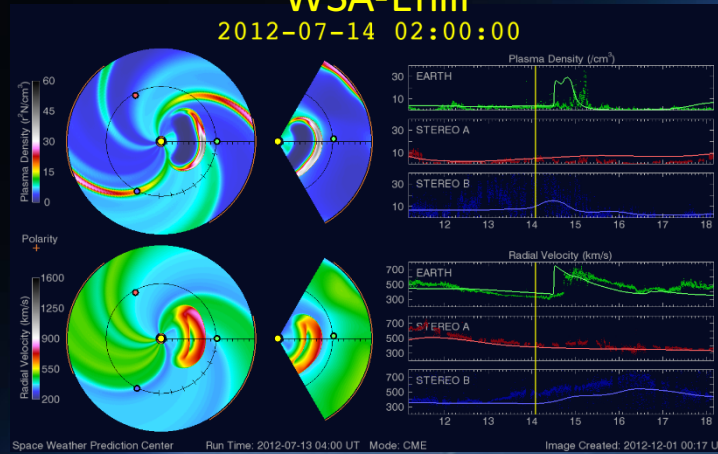
# CME Analysis Tool



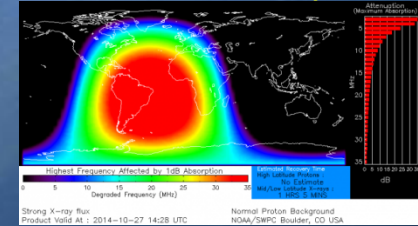
## WSA



WSA-Enlil  
2012-07-14 02:00:00

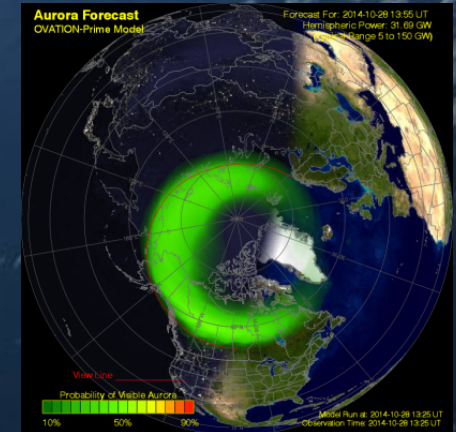


## HF Com Absorption

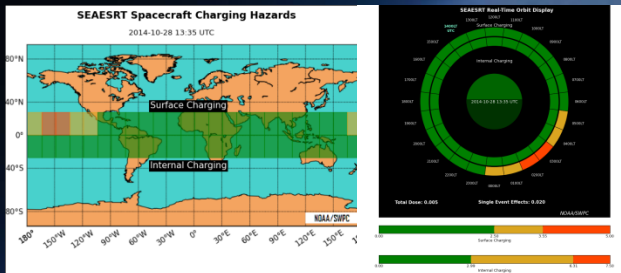


# Aurora Forecast Model

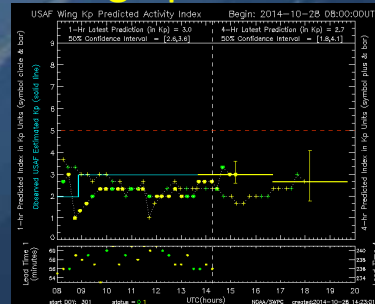
## - 30 Minute Forecast



# Satellite Environment Model

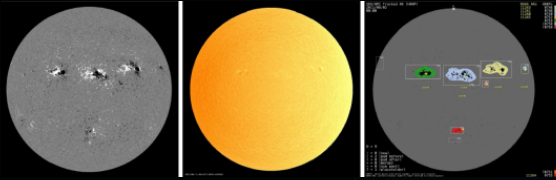


## Wing Kp Forecast

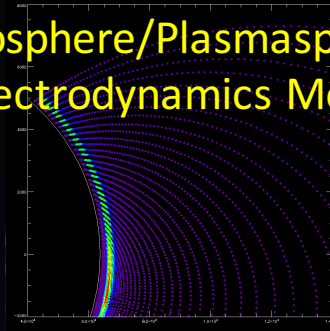


# Models Under Development at the Testbed

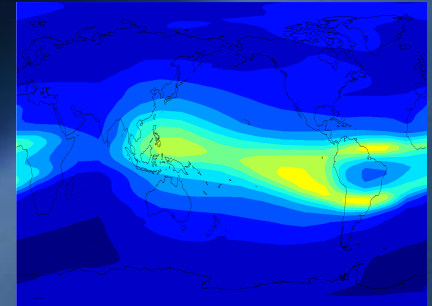
## Solar Flare Forecast



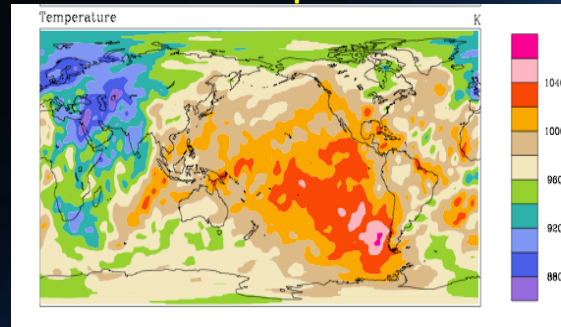
## Ionosphere/Plasmasphere/ Electrodynamics Model



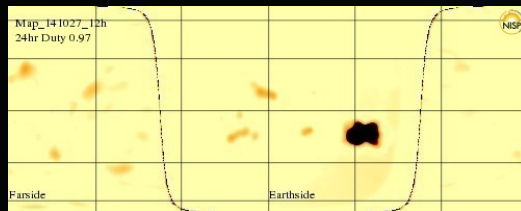
## Global TEC Assimilative Model



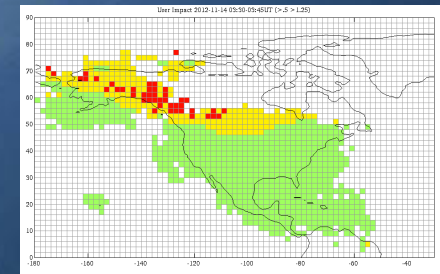
## Whole Atmosphere Model



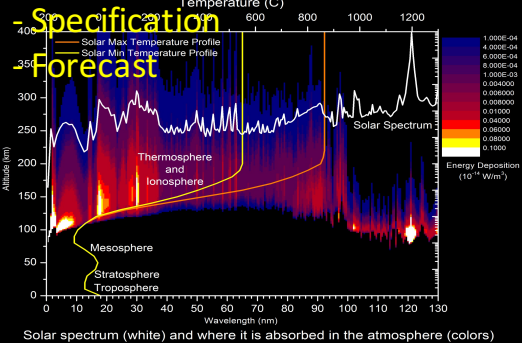
## Far-side Analysis



## ROTI GPS Product

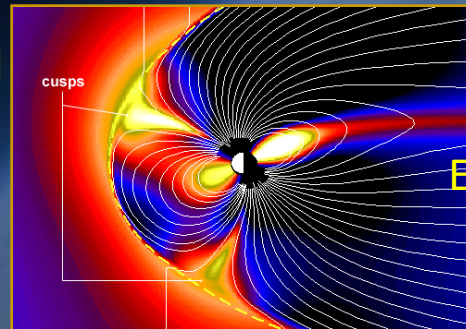


## Solar EUV Irradiance Model

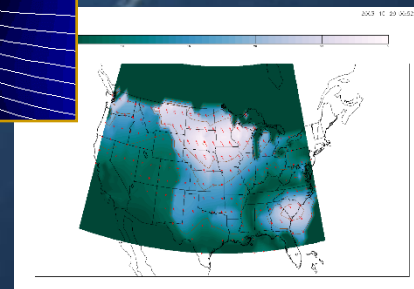


5 April 2016

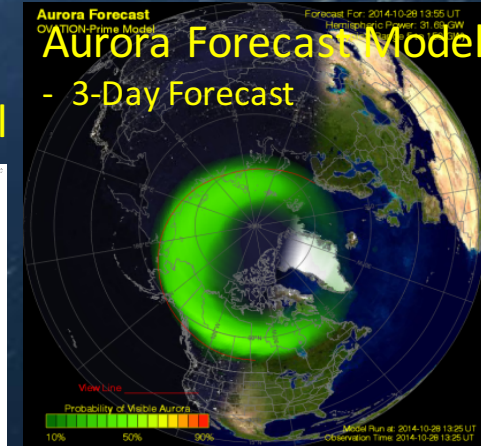
## Geospace Model



## Electric Field Model



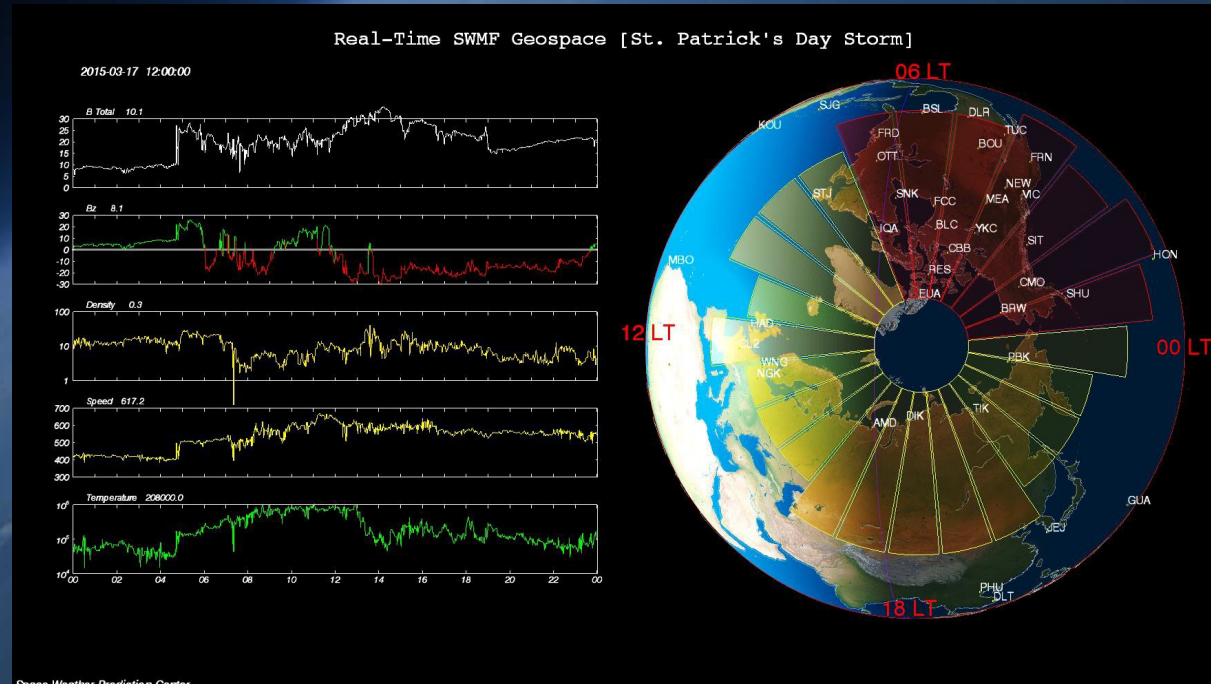
## Aurora Forecast Model - 3-Day Forecast



# Accomplishments of the Last Year

## Geospace Model Delivery to NCO

- U. Michigan SWMF model was selected through a community wide competition in 2014
- Geospace model has been handed off to NCO for transition to operations.
  - Currently undergoing 30-day test run on WCOSS
  - Will provide regional forecasts to the electric power industry on where impacts may be greatest.



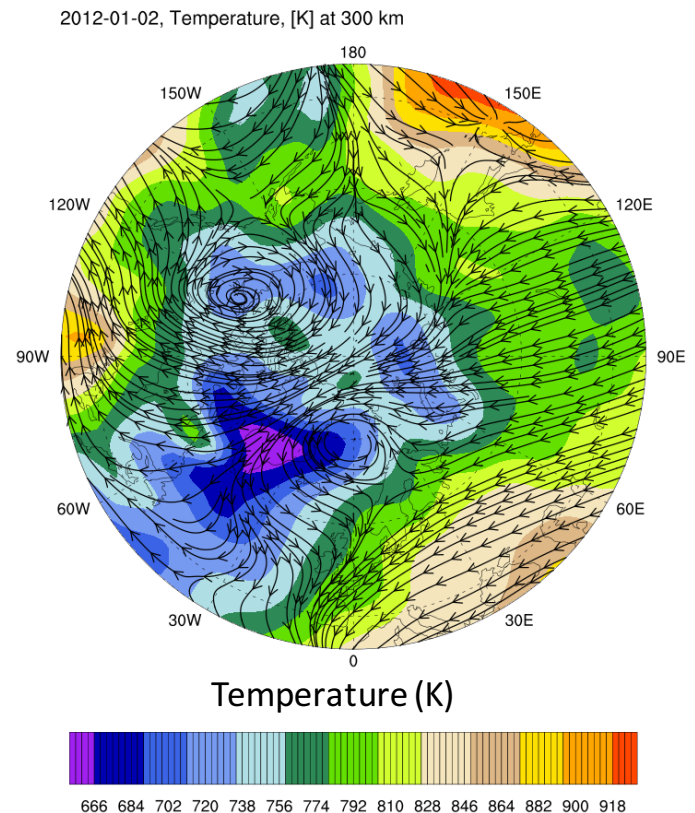


# Accomplishments of Last Year

## Whole Atmosphere Model Running in Real-time

- Coupled Atmosphere-Ionosphere modeling system is being developed at NOAA/SWPC
- Whole Atmosphere Model (Extended GFS/GDAS)
  - Running in realtime on WCOSS-Dev
    - Will provide input to ionospheric model
    - Will provide forecasts of thermospheric neutral density (satellite drag)
- Ionosphere Plasmasphere Electrodynamics model
  - Will begin parallel run this year
- Fully coupled model system in 2018

WAM: High velocity wind vortices driven by geomagnetic activity

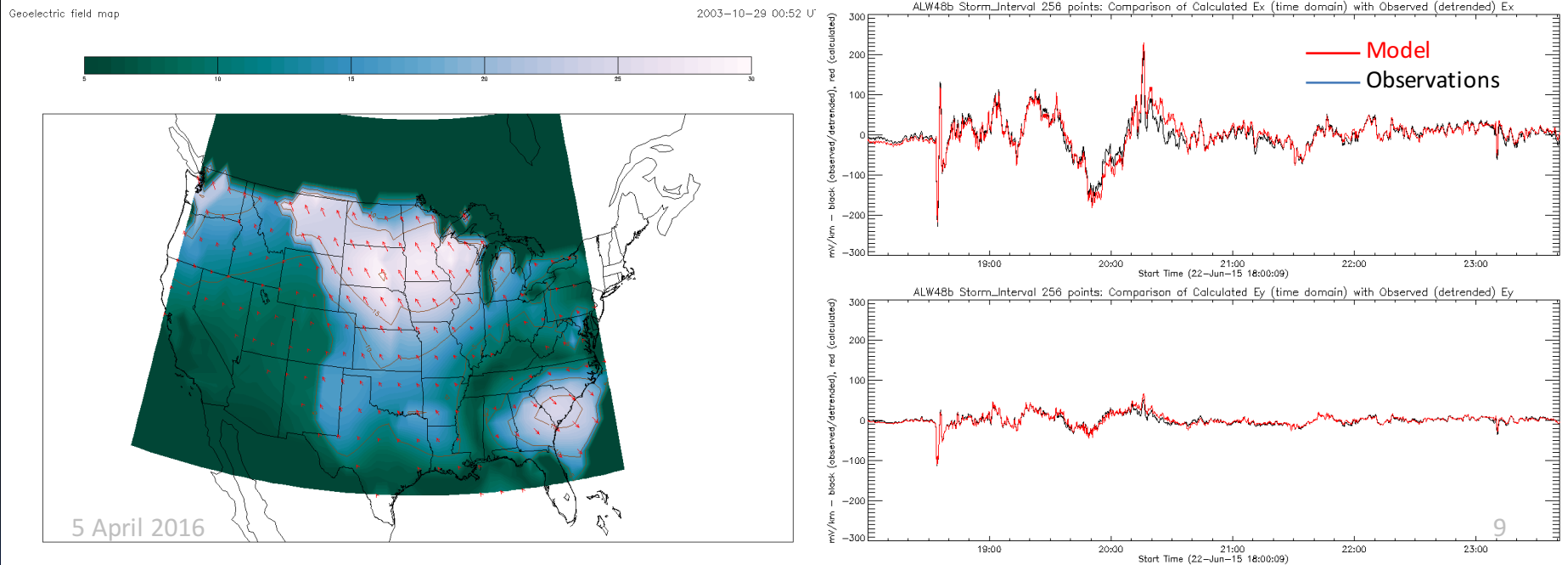




# Accomplishments of Last Year

## Geoelectric Field Model Ready for Testing

- This model is being developed in conjunction with NASA and USGS
- Geoelectric Field Specification Product
  - Based on customer demands (regional electric field to input to electric grid models)
  - Test product developed
    - Being vetted with customers now
    - Released to public soon



# Plans for the Coming Year

- Sun:
  - New ADAPT model from the Air Force Research Lab to be introduced as a test product
    - Provide input to the WSA-Enlil models
    - Provides forecasts of solar radio and EUV products
- Solar Wind:
  - DSCOVR satellite at L1 (in the solar wind) to become operational (21 April?)
- Magnetosphere:
  - Geospace:
    - Model to become fully operational
    - New products to be introduced and tested by customers
- Ionosphere:
  - Ionosphere-Plasmasphere-Electrodynamics (IPE) model to run in real-time on WCOSS-Dev
  - Initial one-way coupling to the Whole Atmosphere Model (Extended GFS)

# Support for Space Weather

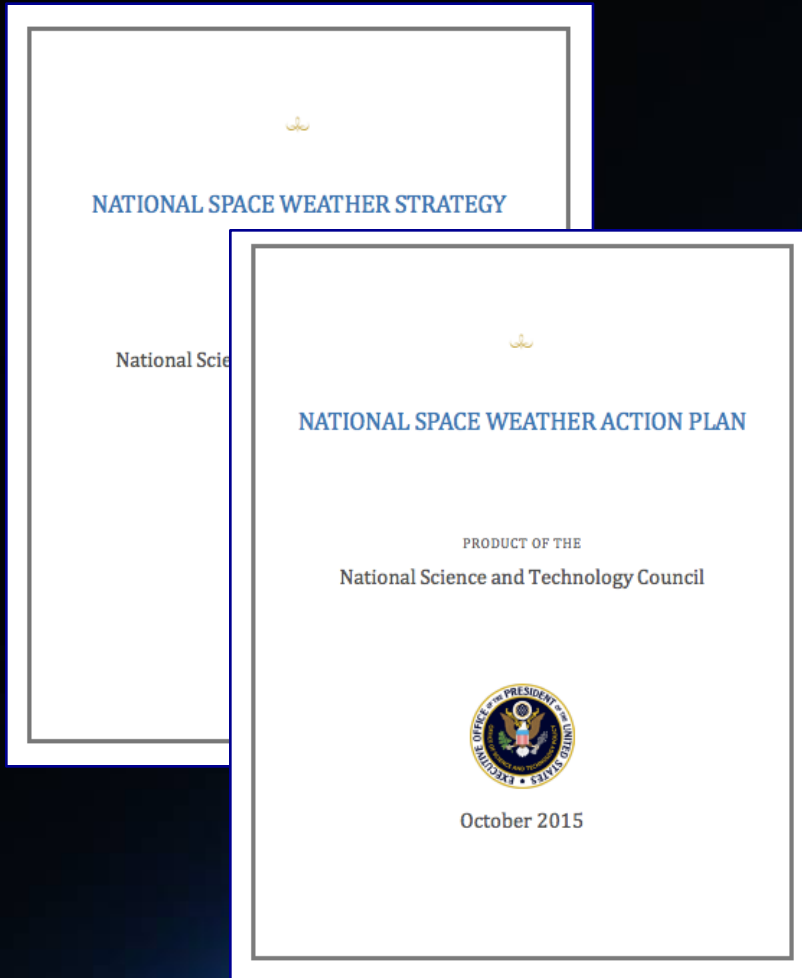
## from the highest levels



- White House OSTP Recognizes the Importance of Space Weather
  - Developed the Space Weather Operations, Research, and Mitigation (SWORM) program
  - Developed the companion Space Weather Action Plan (SWAP)
    - NOAA, DHS, NASA, DOD, DOI,
- Define a complete program for operational space weather support.
- Identify gaps (observations and research).
- Improve R2O and O2R

# Space Weather Action Plan

## Highlights Observations, Data, and Research



- Chartered under White House Office of Science & Technology Policy (OSTP)
- Chaired by OSTP, National Weather Service, and Dept. of Homeland Security.
  - OSTP: policy lead
  - NWS: operational forecasting
  - DHS: mitigation and response
- Released 29-October-2015
- Outlines goals for operations, research, mitigation, and response in preparation for extreme events.

*For copies, google "OSTP space weather"*  
[https://www.whitehouse.gov/sites/default/files/microsites/ostp/final\\_national\\_space\\_weather\\_action\\_plan\\_20151028.pdf](https://www.whitehouse.gov/sites/default/files/microsites/ostp/final_national_space_weather_action_plan_20151028.pdf)



# Space Weather Action Plan

## Table of Contents

1. Establish Benchmarks (how big could a storm be?)
2. Enhance Response and Recovery
3. Improve Protection and Mitigation
4. Improve Assessment, Modeling, Prediction of Impacts on Critical Infrastructure
5. Improve Services through Advances in Understanding and Forecasting
  - 5.3 Establish Baseline Observations
  - 5.6 Improve Transition of Research to Operations
6. Increase International Cooperation

# Baseline Operational Observing System

## Critical measurements for operational SWx forecasting

### SWAP Section 5.3

Defines observations required by operational space weather forecasting centers to execute baseline mission.

5.3.2 Sun-Earth line (L1) Orbit: sustain solar coronagraph CME and solar wind measurements

Current Capabilities

NASA  
SOHO



NOAA  
DSCOVR



Future Capability [NOAA SWx Follow-On](#)

5.3.3 Geostationary Orbit: sustain or enhance solar imagery, X-ray irradiance, energetic particle, mag field

Current Capabilities

NOAA  
GOES RSTU



Future Capability ?

5.3.4 Ground-based: sustain or enhance solar imaging and magnetic field measurements

Current Capabilities

NOAA-NSF  
GONG



Future Capability ?

5.3.5 Ground-based: sustain or enhance solar radio measurements

Current Capabilities

USAF  
RSTN



Future Capability ?

5.3.6 Ground-based: sustain or enhance the real-time geomagnetic field measurement network

Current Capabilities

USGS  
MagNet

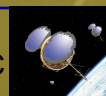


Future Capability [INTERMAGNET?](#)

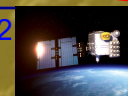
5.3.7 LEO/MEO: enable and sustain GNSS radio occultation measurements for ionospheric characteristics

Current Capabilities

NCAR  
COSMIC



Future Capability [COSMIC-2](#)



[CSP Data?](#)

5.3.8 Ground-based: sustain or enhance the worldwide neutron monitoring (NM) network

Current Capabilities

NSF  
Polar NM



Future Capability [NOAA-NSF Global NM Net](#)



# SWAP Actions 5.6.2 and 5.6.3

## Formalize/Define R2O and O2R processes in SWx

- 5.6 Improve the effectiveness and timeliness of the process that transitions research to operations

5.6.1 NASA and NSF lead: signed memorandum of understanding between modeling and forecasting centers (R2O).

5.6.2 DOC and DOD lead: complete plan for improving, testing, and maintaining operational forecast models and enabling operations to research feedback (O2R).

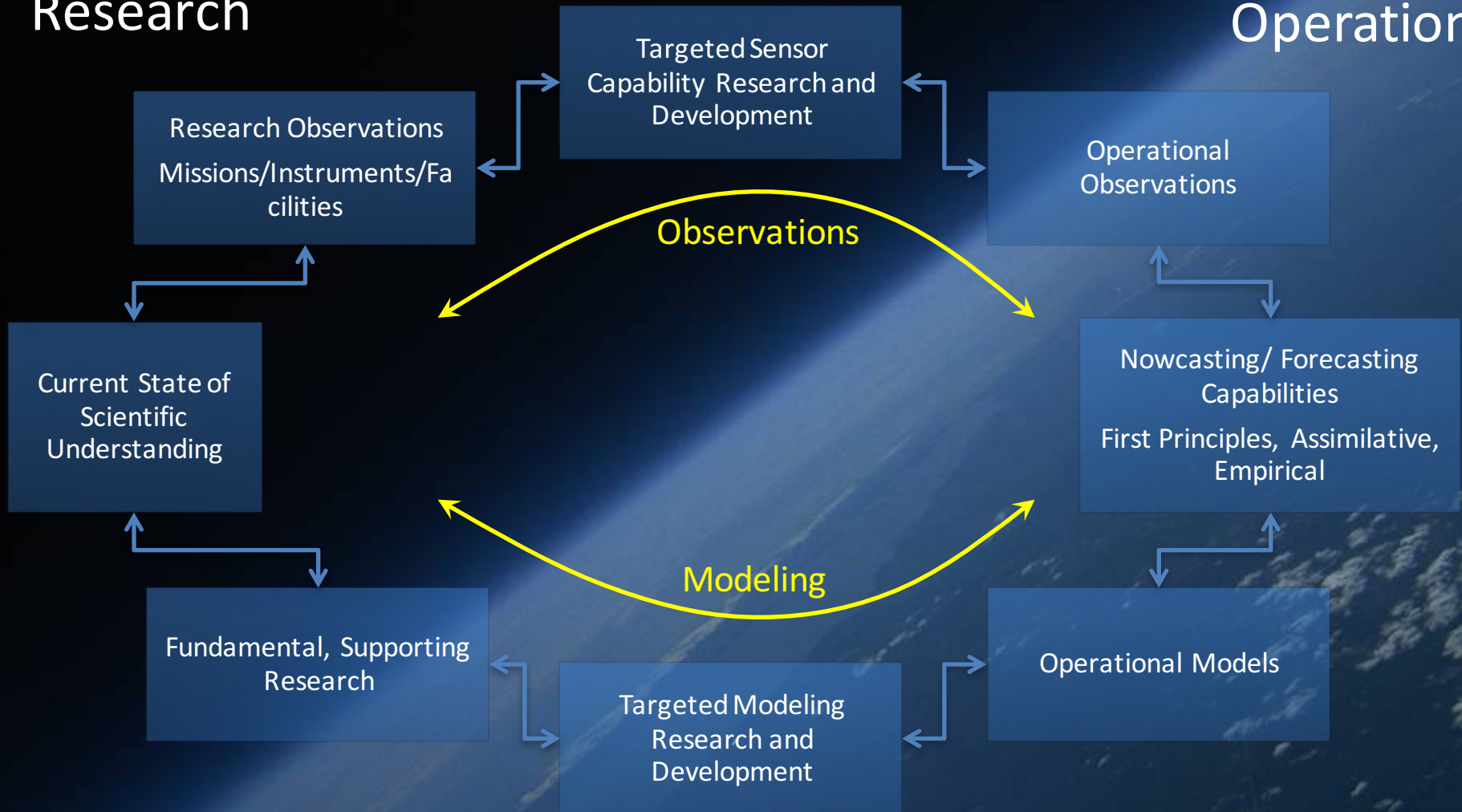
### Progress to date:

- MOU drafted between NASA and NOAA/NWS/SWPC.
- OMB briefed on R2O and O2R concepts by NASA, NSF, NOAA, DOD on 2/29/16.
- Draft white paper on O2R requirements outlined.

# Elements of R2O and O2R System

## Research

## Operations

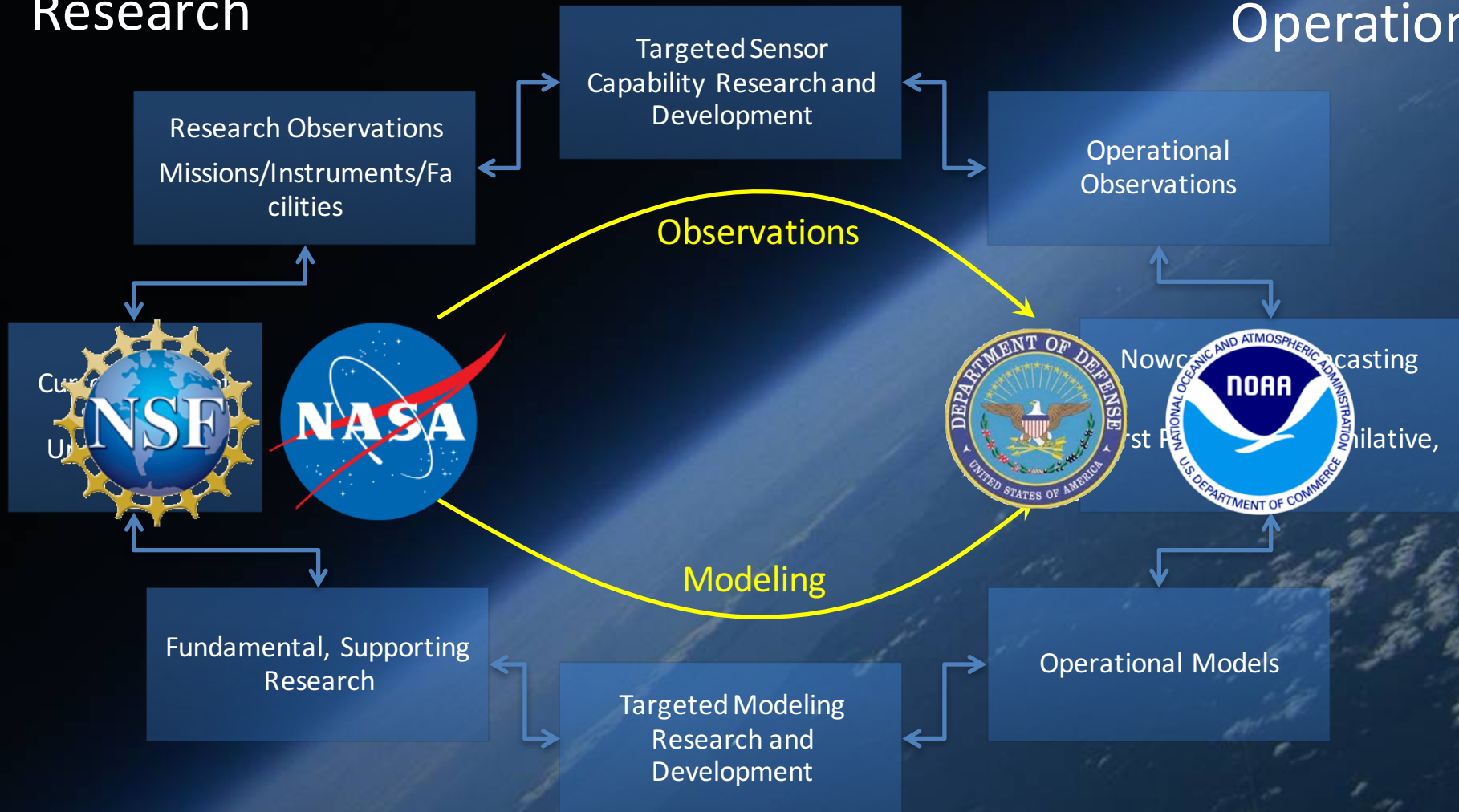




# Elements of R2O and O2R System

## Research

## Operations



# An Operations to Research Paradigm

- Problem:
  - The research community loses access to the (sometimes heavily modified) operational code.
  - The research community lacks sources of funding for “applied research” work on operational models.
  - The research community is very concerned over intellectual property rights
  - The operations community typically lacks the scientific knowledge to upgrade the codes with new physics and/or algorithms.

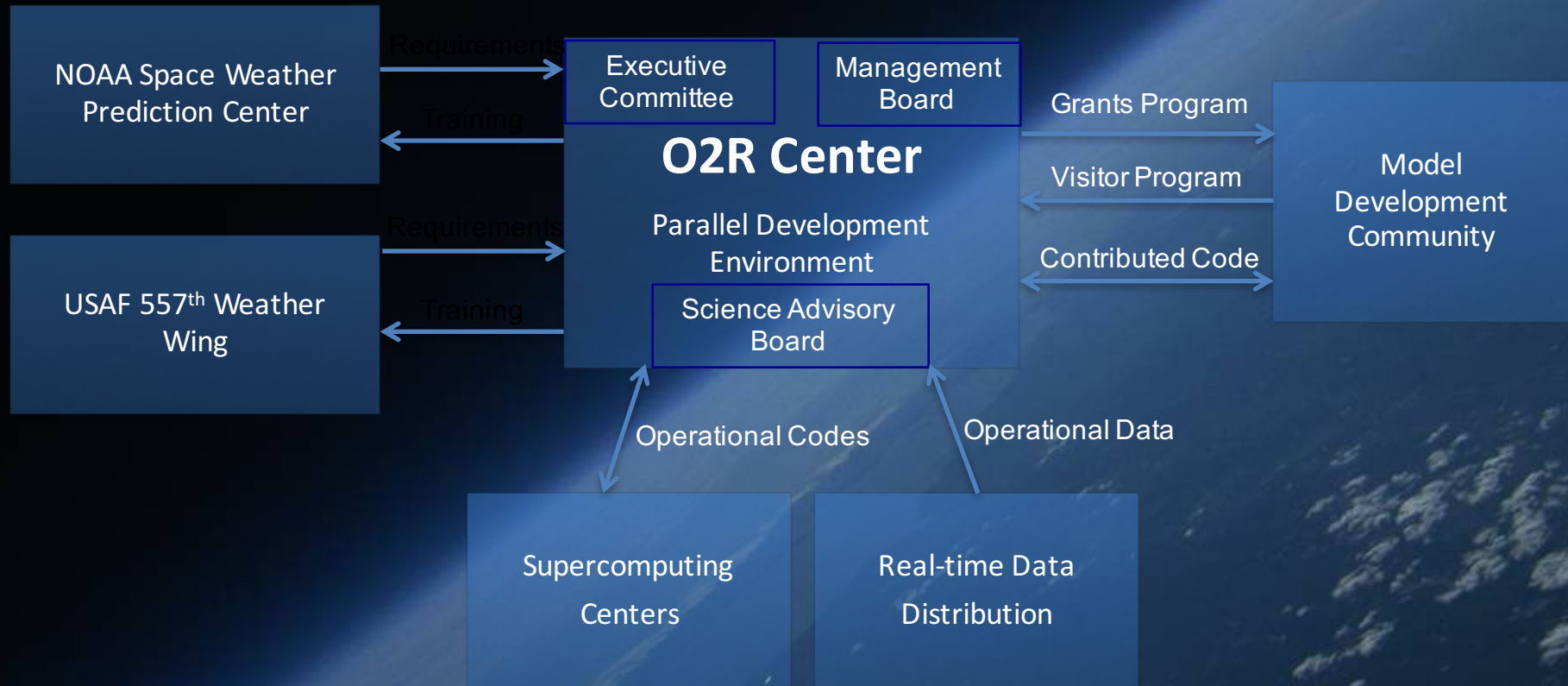
Example: The first SWx model in operations (WSA-Enlil) has not been updated since it became operational in 2011.
- Proposal:
  - **An O2R “facility” where parallel versions of operational codes can be modified by researchers and tested with real-time or archived data against original code.**
  - Multi-agency support for “applied research” grants to the model development community.

# O2R Vision

## Bridge between Operations and Research Communities

### Operations

### Research



Terrestrial weather analogs: JCSDA, NCAR DTC, CTB, NGGPS project, etc.

# R2O & O2R: Next Steps

5.6.1: R2O Center: Finalize MOU between NASA and NOAA/NWS/SWPC.

5.6.2: O2R Center: Multi-step process

- Defining the issue and requirements (Publish June 2016)
- Gather input and feedback: Community meeting on concepts of operation, logistic issues, charter development, etc: **August 16—17, 2016, Boulder, Colorado**
- Finalize O2R plan for submission to OSTP: October 2016.



# Summary

- SWPT is making progress towards the introduction of new space weather models to support operations
- New recognition of the importance of space weather at high levels in government is providing leadership and guidance for agencies to coordinate
  - Research to Operations
  - Operations to Research